



Bioenergy: The potential for rural development and poverty alleviation

Summary for policy-makers

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Bioenergy: The potential for rural development and poverty alleviation

This publication summarizes the report 'Bioenergy, rural development and poverty alleviation' by GNESD member Centres of Excellence. This summary for policy-makers and other reports can be freely obtained from the GNESD Secretariat and also from the website: www.gnesd.org

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GNESD
GLOBAL NETWORK ON ENERGY FOR SUSTAINABLE DEVELOPMENT
Facilitated by UNEP



UN-Energy

Global Network on Energy for Sustainable Development (GNESD)

GNESD is a UNEP-facilitated network of Centres of Excellence dedicated to improving energy access for the poor in developing countries, and helping those countries with energy access policy recommendations to achieve their Millennium Development Goals (MDGs). The current member Centres of Excellence from developing and emerging economies include China, India, Thailand, Brazil, Argentina, South Africa, Kenya, Senegal, Tunisia and Lebanon. The network members are all renowned institutions in energy topics. GNESD membership facilitates coordinated analytical work, the exchange of information and policy analysis on environmentally benign energy-policy options relevant to national and regional governments.

Scientific research findings produced by the network are freely available to governments and regional organizations for formulating policies and programmes. The private sector can also use these findings in their efforts to attract investments.

GNESD activities are based on the firm belief that access to affordable, modern energy services is a pre-requisite for sustainable development and the alleviation of poverty. These activities are designed to:

- strengthen South-South knowledge exchange and collaboration on environmentally benign energy access issues;
- create a communications infrastructure that makes it easier for member centres to share experiences and draw on each other's strengths, expertise and skills; and
- engage member centres more actively in national/regional policy dialogue and outreach activities.

GNESD is one of several Type II partnerships in the field of energy that were launched at the World Summit on Sustainable Development (WSSD) in Johannesburg, September 2002.

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GNESD members who authored the country reports that provided important background information in preparing this SPM include:

Africa:

ENDA-TM, Environnement et Développement du Tiers Monde is a non governmental organisation based in Dakar, Senegal. Its objectives and activities contribute to a better technical, economic and socio-cultural understanding of energy issues in African countries (coordinating author: Touria Dafrallah; contributing authors from ENDA and the West African region: Alassane Ngom, Verena Omer, Ishmael Edjekumhene and Paula Edze).

AFREPREN/FWD, The African Energy Policy Research Network/Foundation for Woodstove Dissemination, Kenya brings together 106 African energy researchers and policy makers who have conducted policy studies in 19 African countries (authors: Stephen Karekezi and John Kimani).

ERC, Energy Research Centre, University of Cape Town, South Africa, is a leading institution for development of African energy and energy-environment policy, development and capacity building (author: Gisela Prasad).

Latin America:

Fundación Bariloche (IDEE/FB), The Bariloche Foundation is a private, non-profit institute founded in 1963 to further research, training, technical assistance, diffusion and other activities. It is based in San Carlos de Bariloche, Argentina (authors: Daniel Bouille and Gonzalo Bravo).

CentroClima at the Federal University of Rio de Janeiro in conjunction with CENBIO – University of São Paulo, Brazil (authors: José Goldemberg, Emilio Lèbre La Rovere, Suani Teixeira Coelho, André Felipe Simões, Patricia Guardabassi, Renata Grisoli and Manuel Moreno).

Asia:

AIT, The Asian Institute of Technology, based in Thailand, is an international postgraduate institution with a mission to develop highly qualified and committed professionals who will play a leading role in the sustainable development of the Asian region (authors: S. Kumar, P. Abdul Salam, Ram M. Shrestha and Manjula Siriwardhana).

TERI, The Energy and Resources Institute, located in New Delhi, India, was established in 1974 with an initial focus on information dissemination. Research activities in the fields of energy, environment and sustainable development were initiated in 1982 (authors: Akanksha Chaurey, Akshima Ghate and Abhishek Kar).

ERI, The Energy Research Institute (ERI), part of China's National Development and Reform Commission (NDRC), is the national, governmental energy economics and policy study institute. ERI's research fields cover a wide range of energy policy issues (Zhao Yongqiang and Gao Hu).

GNESD members also reviewed the SPM and provided comments and suggestions.

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Bioenergy's potential for rural development and poverty alleviation

Most of the world's poor dwell in rural communities with limited or no access to modern energy services. It is widely acknowledged that the majority of people in developing countries depend on 'traditional biomass'. The International Energy Agency (IEA) estimates that 2.7 billion people worldwide are without access to clean cooking facilities, 84% of whom are found in rural communities, where they depend on traditional biomass to meet their daily cooking needs (IEA 2011). Even with projected economic growth, technological progress and considerable increase in investments in modern energy services by 2030, the IEA predicts that, as a result of population growth, about 2.7 billion people will still lack access to clean cooking facilities by 2030 unless significant new policies are put in place now (IEA 2011). It has been reported that modern bioenergy could play a significant role in addressing the global clean cooking facility gap with specific reference to biogas and advanced cookstoves. Additionally, the development of modern bioenergy, derived from sustainably derived biomass resources, is seen by most local governments as an alternative energy option with good potential to alleviate poverty and to contribute to rural development. A careful balance of policy options, taking into account the different pressures and competition on land and related resources, need to be considered prior to commencing bioenergy activity (UN-Energy, 2010). In this study, GNECD Centres in Africa, Asia and Latin America have analyzed biomass resource potential, energy policies promoting the deployment of bioenergy and how bioenergy can be effectively employed in bringing about rural development and poverty alleviation in eighteen countries across the globe. Findings from the study showed some interesting developments and success stories in the application of bioenergy for socio-economic improvements in rural communities in emerging economies and developing countries. It was observed that a comprehensive strategy that targets the use of environmentally and socially benign bioenergy (in an integrated manner with other development activities) could be essential in bringing about rural socio-economic development. The study suggests policy recommendations for consideration by decision-makers in promoting the use of bioenergy in developing countries and emerging economies.

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Summary

Modern bioenergy that is sustainably obtained has the potential to mitigate climate change and to bring about rural development and socio-economic improvement. Eight GNESD Centres in Africa, Asia and Latin America have analyzed bioenergy, asking how it can be effectively employed to result in rural development and poverty alleviation in eighteen countries across the globe. This was part of the network's study under the Bioenergy Theme.

The analysis included:

- assessment of the potential of bioenergy (i.e. solid, liquid and gas) for rural development and socio-economic development
- barriers to the use of bioenergy
- sustainability issues of bioenergy
- policy options and recommendations for the effective utilization of bioenergy for rural development and poverty alleviation

Findings and policy recommendations

An effective way of alleviating poverty is through the energization of productive activities in order to improve quality of life and incomes. Most importantly, the introduction of these bioenergy technologies can help poor rural people when they are integrated into a comprehensive development strategy. This study undertaken by the GNESD Centres of Excellence has shown that, depending on the scale, bioenergy technologies require high organisational efforts and a minimum level of infrastructure, income and knowledge, elements that must be developed in most of the rural sector of several developing countries and emerging economies.

Ongoing sustainability debate and the criteria being developed provides immense opportunities for bioenergy to be done correctly, thus providing preconditions for the acceptability and long-term development of the sector itself. It was found that the countries studied were at different levels with regards to regulations for bioenergy sustainability.

The study proposes the following policy recommendations for consideration:

1. Countries must take sustainability concerns into consideration when developing policies and programmes for bioenergy. In particular, long-term supports (investor security/visibility) as well as mapping /zoning have proved crucial in the Brazilian experience. The effective implementation of such policies, including sustainability criteria, requires appropriate processes and institutions to be put into place, as well as regular monitoring and verification.
2. Setting-up supporting regulatory frameworks to ensure sustainable production and use of bioenergy at the environmental, economic and social levels.
3. Instituting sustainability approaches to help insure the sustainable production and use of bioenergy. This will safeguard the livelihood systems of the poor and vulnerable.
4. Implementing sustainability approaches that should primarily targets the in-country production, processing and uses of bioenergy and ensure the improvement of local populations' livelihoods and energy and food security.
5. An assessment of the quantity, geographical distribution and accessibility to biomass, as well as any potential competition with other industries for the resource need to be evaluated before commencing any bioenergy initiatives.
6. Increased national support for research and development (R&D) in high crop-yield plant-breeding. This together with adequate environmental legislation, has the added benefit of reducing land use and deforestation problems.
7. Governments should increase their investments in research and development (R&D) of bioconversion activities and provide support to reach the commercial stage.
8. A dedicated institution for bioenergy research, development and promotion should be 'carved' out of the existing national institutional maze of multiple organizations with overlapping roles in

most developing countries. At the same time, it is important that the dedicated research, development and promotion institution has sufficient ties to existing institutions to ensure integration and also to maximize the opportunities presented by the various organizations.

9. Integrating the bioenergy industry into existing industries. Such creative inter-linkages would ensure that the existing opportunities and infrastructure are tapped to achieve resource efficiency.
10. Establishing a successful bioenergy industry needs a high degree of organizational effort and a minimum level of infrastructure, income and knowledge; elements that still have to be developed in most of rural sectors in emerging economies and developing countries.
11. Develop and implement national bioenergy policies. Such policies should set clear and realistic targets for bioenergy in the national energy mix and develop strategies, including proper incentive mechanisms to help achieve set targets.
12. Ensuring transparency in bioenergy financial resources allocation. To put in place supporting measures to enhance the capacity to implement the sustainability of bioenergy and promote environmentally and socially friendly bioenergy markets.
13. A market approach could be used to promote technology transfers on a self-sustainable basis, rather than remaining dependent on 'one time' grants. This should be the case for technologically matured bioenergy options.
14. Innovative financing schemes should be explored to finance bioenergy projects.
15. Innovative revenue-sharing mechanisms should be considered if bioenergy (such as co-generation) is to be utilized as an effective poverty alleviation tool. An example is the equitable sharing of proceeds from the sale of co-generated electricity among the stakeholders (including the small-scale farmers who provided the sugarcane) as practised in Mauritius. Another example is to use some of the revenue from co-generated electricity to provide social amenities such as health posts, schools and clean water, as well as improving road networks in rural areas, as is being done by sugar mills in Kenya.
16. Implementing incentives for the adequate development of regional support networks for each technology; promoting and supporting association among very small producers; promoting the commercial availability of small scale-biomass technologies.
17. Integrating biomass energy support policies into wider development policies to ensure coherence in objectives and efficient use of resources. This helps to assign priority levels, identify bottlenecks and complement measures (e.g. rationale energy use in the transport sector and biofuel promotion).
18. The promotion and dissemination of high efficiency cookstoves and the use of biomass briquettes and pellets from sustainably derived agricultural and forest/wood residues.

Why bioenergy for rural development and poverty alleviation?

Most of the world's poor dwell in rural communities in developing countries, with limited or no access to modern energy services (IEA 2011; Bierbaum and Fay, 2010; GNESD 2006). This lack of access to modern energy services not only affects economic productivity but is also a stumbling block to the adequate provision of other essential basic services such as health care and education. Utilization of 'traditional biomass' for cooking and heating is already prevalent in most rural communities in developing countries (AGECC, 2010). Recent empirical study evidence indicates that access to modern energy in impoverished communities helps provide the basis for alleviating poverty and producing rural development (Casillas and Kammen, 2010).

The International Energy Agency (IEA) estimates that 2.7 billion people worldwide are without access to clean cooking facilities, 84% of whom are found in rural communities and are presumed to depend on traditional biomass to meet their daily cooking needs (IEA 2011). Even with projected economic growth and technological progress and a considerable increase in investments in modern energy services by 2030, the IEA projects that 2.7 billion people will still lack access to clean cooking facilities unless significant new policies are put in place now to reverse the forecast trend (IEA 2011). Increased population growth is likely to cancel out the considerable gains in technological know-how, investments and economic development by 2030 unless significant investments, birth-control measures and overall ambitious new policies are put in place, especially in energy-poor communities.

The over dependence on wood fuel to meet cooking and heating needs is a primary driver for deforestation in impoverished communities. Women and children spend significant amounts of time collecting the biomass for cooking and heating. The efforts spent in collecting firewood have significant negative implications on the lives of the collectors, especially the educational prospects of children.

Inefficient cooking, lighting and heating devices emit significant amount of polluting smoke, which kills nearly 1.6 million women and young children prematurely every year and causes a range of chronic illnesses and other health problems. This is a result of the hazardous compounds and particulate matter that are released from burning firewood (Box 1). The IEA, using WHO estimates, predicts over 1.5 million premature deaths per year by 2030 (the equivalent of 4000 deaths a day) due to the use of biomass in inefficient stoves (IEA, 2010).

Thus the benefits of using bioenergy to provide clean and efficient energy services to rural communities cannot be over-emphasized. However, there are growing concerns regarding the environmental sustainability issues of bioenergy expansion, food security and diversion of land from agriculture, forestry or other uses to the growing of bioenergy crops. These concerns nevertheless provide an opportunity for bioenergy to be done correctly. Diverse biomass feedstock types are utilized in different bioconversion technological processes. The heterogeneity of these feedstock types, namely manure, food crops, agricultural residues, forests and sawmills waste, requires different bioenergy conversion platforms in addition to their respective unique value chains (Ackom, 2010). Technological platforms could range from biological (anaerobic fermentation, e.g. biogas), biochemical (both first- and second-generation biofuels) and thermochemical (e.g. pyrolysis and gasification) to direct combustion in combined heat and power systems. The various bioconversion technological platforms are at different levels of maturity, ranging from matured technologies as seen in anaerobic fermentation (biogas); corn ethanol; sugarcane ethanol as well as direct combustion for heat and power applications to those at the R&D level, including cellulosic ethanol from agriculture and forestry residues (also known as second-generation biofuel).

Done correctly, bioenergy can contribute to providing clean energy access in rural communities, thus helping to create new economic opportunities, generate more revenue and bring about rural development. Bioenergy offers new investments into the agricultural sector with the potential to provide market and employment opportunities for an estimated 2.5 billion people worldwide who depend on agriculture, including 900 million rural poor (FAO, 2009).

Where the bioresource exists, a comprehensive strategy that targets the use of bioenergy in rural development and poverty alleviation which also safeguards ecosystem integrity and complements other existing development plans/activities should be recommended.

The growing concern regarding the lack of energy access has resulted in the United Nations dedicating 2012 as the 'International Year of Sustainable Energy for All'. Bioenergy has a significant role in helping achieve global energy access, as recently highlighted in an IEA (2011) report.

Box 1. Concerns associated with traditional biomass as a cooking fuel

Concerns posed by the high and persistent dependence on traditional biomass for cooking are now well known. The smoke emitted by the combustion of biomass fuels in traditional cookstoves contains several hazardous pollutants, including particulate matter, carbon monoxide, nitrogen dioxide and formaldehyde, as well as polycyclic organic matter, including carcinogens like benzopyrene. The problem worsens when these stoves are not vented to the outside, producing pollution levels often ten to thirty times those recommended by health agencies. A number of studies have been carried out on household energy use and the health impacts associated with indoor air pollution (IAP) in India (Deasi *et al.*, 2004). Usage of traditional biomass in unimproved, open stoves causes emissions of substantial amounts of harmful pollutants. Indoor air pollution levels in rural households are often much higher than outdoor air pollution in cities. For instance, typical levels of PM₁₀ in rural households range from 300 to 3,000 micrograms per cubic metre ($\mu\text{g}/\text{m}^3$) (WHO 2002), whereas even in the most polluted cities levels rarely exceed 150 $\mu\text{g}/\text{m}^3$. Globally, indoor air pollution from solid fuel use is responsible for 1.6 million deaths, with the overall disease burden (in Disability-Adjusted Life Years or DALYs, a measure combining years of life lost due to disability and death) exceeding the burden from outdoor air pollution by a factor of five.

WHO has reported that almost 40% of acute respiratory infections (ALRI), more than 20% of chronic obstructive pulmonary disease (COPD) and almost 3% of DALYs are caused by IAP from the burning of solid fuels (Arcenas *et al.*, 2010). This makes IAP the second most important environmental risk factor after water, sanitation and hygiene (WHO, 2002). Further, indoor air pollution was responsible for more than 1.5 million deaths worldwide in 2000, making reliance on traditional biomass one of the ten most important threats to public health. Also, indoor air pollution from burning traditional biomass increases the risk of chronic obstructive pulmonary disease, acute respiratory infections among children, cataracts, adverse pregnancy outcomes, pulmonary tuberculosis, asthma and cancer in women.

In this study, GNESD Centres in Africa, Asia and Latin America have analyzed bioenergy and examined how it could help in providing rural development and poverty alleviation in eighteen countries across the globe. Eight GNESD centres were involved in this study (Box 2).

Box 2: The Reporting Centres

GNESD CENTRE	Countries covered in the report
AFREPREN	Kenya, Mauritius
CENBIO, CENTRO CLIMA	Brazil, Colombia
ERC	South Africa, Mozambique and Malawi
ERI	China
FOUNDATION BARILOCHE	Argentina, Chile, Uruguay and Paraguay
AIT	Thailand and Indonesia
ENDA	Senegal, Ghana and Mali
TERI	India

Full centre reports are available at: www.gnesd.org

The GNESD centres investigated the following questions:

- Which biomass types could be effectively utilized to bring about rural development and poverty alleviation?
- Are there successful case studies that could be replicated?
- Does the current energy policy provide an enabling environment for promoting bioenergy use?
- The existence of bioenergy sustainability requirements in the countries studied.
- What are the barriers that hinder the utilization of bioenergy?
- Proven policy options were identified and recommendations made.

Success stories of bioenergy and its role in rural development and poverty alleviation

Several factors need to be considered in determining the quality of life. Any such analysis will require, for example, that the typical basis of dollars per day income levels be supplemented with an assessment of the costs of a basic basket of goods and services, also non-monetary incomes, access to social benefits etc. Additionally, rural development is brought about by a myriad of agents all acting together and not just bioenergy. It was difficult within the scope of the study to collect data that empirically accesses the monetary and non-monetary incomes and social benefits associated with the quality of life that bioenergy brings in the selected countries. What this study has however done is to present success stories that suggest the utilization of bioenergy as a good agent in helping to achieve rural development and poverty alleviation. Bioenergy has been used in a number of applications, such as providing electricity, improving the agricultural yield in an impoverished farming community and providing clean drinking water among other positive consequences, including the development of local economic activities. Additionally, the use of bioenergy has led to reduced efforts regarding the collection of fuelwood and drudgery. In Mauritius, for example, revenue from the sale of electricity from combusting bagasse (a waste product in sugarcane manufacturing) is shared equitably in the community. The case study below provides further information on the use of bioenergy to bring about socio-economic improvements in rural communities.

Case study 1: Socio-economic benefits of biomass-powered irrigation in a rural community, Bangalore, India

In this example, a biomass-based gasifier power plant provides electricity to Tumkur District's Koratagere cluster (nearly 100 km from Bangalore). Prior to setting up biomass gasifiers, a farmer could only grow one crop on a piece of land due to lack of irrigation facilities. However, since establishing the biomass gasifier, farmers have been able to grow at least three crops in a year due to irrigation powered by bioenergy.¹ Farmers no longer have to rely on direct precipitation (which is unreliable) for their crops. The additional benefit of bioenergy to the community is the improved quality of life that the regular availability

of electricity for lighting and related services brings (e.g. provision of clean water). This project was supported by UNDP, and there are plans to replicate this model in other villages.

Case study 2: Bioenergy for rural development in Sunderbans, India

On Gosaba Island in the Delta Region of Sunderbans, West Bengal State, 2 million out of 3 million inhabitants did not have access to electricity prior to the setting up of a 500 kW (5 x 100 kW) biomass gasifier dual-fuel power-generation system (70% biomass + 30% diesel) in June, 1997. Only sixteen customers were subscribers to begin with, but once the benefits of electrification began to be realized, the customer base increased to about 1150 households. The plant operates 15 hours a day (10:00 am to 1:00 am next day) and charges about Rs 5.6/Kwh from domestic consumers. The cost of the fuel is about Rs. 35 (\$0.78) / 40 kg half dry wood² (one container), and fuel efficiency is about 90 cc diesel + 850-900 g of wood / kWh. By introducing a biomass gasifier, the region has witnessed overall social and economic development. The electrification of the community (using 70% biomass) resulted in the establishment of commercial shops and hotels, which attract people from the nearby village for shopping. This also catalyzed other economic activities and institutions such as banks, improvements in telecommunication systems and internet facilities. Additionally, the electricity is being used to supply drinking water and irrigation, as well as other purposes such as street- and school-lighting. The project provides direct employment to 22 labourers in the operation and maintenance activities (Hitofumi, 2005).

Case study 3: Biopower and job creation in Mysore, India

Two companies namely Plant Pvt Ltd. and South Pole Ltd., worked in cooperation with the Swiss-based MyClimate Foundation to develop and execute the Malavalli Power Plant Project in Mysore, India. The Malavalli Power Plant consists of a 4.5 MW (gross) capacity grid connected biomass based power plant with high-pressure steam turbine configuration. Over a 7-year period the plant generates

¹ The impact of irrigation on watersheds and aquifers was not investigated in this case study. It might be essential to assess the overall impact on watersheds and aquifers of bioenergy and related activities in a future study.

² It is unclear at this point how the wood was sourced. For replicability however, wood need to be derived from environmentally benign sources.

about 193 GWh by using low density crop residues (70%) and other biomass fuels found in the local area. Agricultural residues used include sugar cane trash, coconut fronds, corn cobs, and toppings of plantation wood. The project has contributed well to the rural entrepreneurial development. About 450 new jobs have been created in the crop residues supply chain and about 200 jobs at the Biomass Power Plant and Organic Fertilizer O&M have been created for local residents. The project's contributes approximately Rs. 45 million (approximately 1 million USD) to the rural economy through the biomass supply chain.

Case study 4: Revenue-sharing (from co-generation) in Mauritius

Co-generation in Mauritius benefits all stakeholders through a wide variety of innovative revenue-sharing measures. The co-generation industry works closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders, including the sugarcane smallholder. The equitable revenue-sharing policies that are in place in Mauritius provide a model for replication in other countries. By sharing revenue with stakeholders (and the small-scale farmers), the co-generation industry was able to convince the government (which is very attentive to the needs of the small-scale farmers, as they are a major source of votes) to extend supportive policies and tax incentives to co-generation investments (Deepchand, 2002).

Case study 5: Sugarcane bagasse cogeneration, Brazil

Brazil's biomass power capacity, nearly all co-generation, has been increasing steadily. Capacity reached 7.8 GW by the end of 2010 (REN21, 2011), generating a total of 28 TWh of electricity (IEA, 2011). Most generation is from combined heat and power (CHP) plants at sugar mills using sugarcane bagasse as a feedstock. During the 2010 sugar-harvesting season, sugarcane bagasse generated 18.5 TWh of electricity, including 8.8 TWh of excess electricity that

was exported into the grid³ (Brazilian Ministry of Mines and Energy, 2011).

Case study 5: Garalo village electrification, Mali.

The Garalo village electrification represents a community-level approach to the energy challenges in rural areas of Mali. This initiative was started by the Mali Folkcenter (MFC) and supported by the Dutch government (ECN). The overall budget for the Garalo village electrification initiative was 765,000 USD. This initiative provides electricity to 250 subscribers, private households and community facilities. Additionally, it provides electricity to power 42 public streetlights. The Garalo village electrification project has led to considerable educational progress for students (who can now read at night). Furthermore, local organizational structures have been remarkably developed, including the creation of a *Jatropha* cooperative, a village electricity committee to represent the population in energy questions and the construction of a powerhouse and offices. Electrification has also resulted in increased information and communication technologies such as televisions, radios and personal computers in the village. The initiative has resulted in income-generating activities for farmers and women's groups who participate in *Jatropha* seed production. The generator used is a hybrid power plant (3 x 100 kW) that runs for more than five hours daily on both diesel and pure *Jatropha curcas* oil. The low-voltage overhead grid gives most inhabitants of the village access to electricity. The project produces sufficient electricity to run the generators. All registered households receive an electricity meter.

Case study 6: Biogas project of Beijing Deqingyuan Chicken Farm, China

In China, large and medium size biogas projects have appeared since the late 1970s. In recent years, however with medium and large-scale biogas projects becoming more popular, high-power biogas engines were produced and

³ Co-generation technology is being installed in some countries in Africa making use of lessons from the Brazilian experience. The project Cogen for Africa was launched in mid-2007 and is set to run for six years. The initiative is being implemented jointly by UNEP and the African Development Bank. The project aims to scale up the use of efficient co-generation systems significantly, initially in seven east and southern African countries, including Kenya, Ethiopia, Malawi, Sudan, Uganda, Tanzania and Swaziland. It is being carried out by a GNESD member Centre of Excellence, AFREPREN/FWD. More information on the project can be found at: www.afrepren.org/cfa/

used in these biogas power projects. Currently, biogas is used not only for lighting and cooking, but also as a centralized gas and electricity supply for entire villages. Deqingyuan Chicken Farm, located in Yanqing County of Beijing, is the biggest (unit breeding stock) high-quality egg-production base in Asia, able to produce over 210 tonnes/day of chicken waste, with a breeding stock of 2.1 million for layers and 900,000 for broilers. This 2 MW power plant, with an anaerobic fermentation tank of 12,000 m³ (i.e. 4x3000 m³), was completed in 2008 and can produce 7 million m³ of biogas, generating 14 million KWh annually, as well as a surplus production of heat equivalent to 4,500 tonnes of oil equivalent (toe). The total investment is 62.8 million RMB (9.3 million USD). The biogas project can digest 77,000 tonnes of organic waste and 150,000 tonnes of sewage in the ecological area annually, and its equipment can produce 150,000 tonnes of liquor and 6,600 tonnes of residue annually, which are used as organic fertilizer for about 1,400 ha of fruit trees and vegetables and 2,800 ha of corn plants nearby.

At the same time, the fertilizer can also act as a soil conditioner for agricultural fields, such as increasing the organic components of the soil. The breeding farm can accept 60000 T/a of corn produced by the Yanqing area, giving local farmers a profit of 40 million RMB.

Case study 3: Biogas, India

A group of villages, Pichhaura, Dudapar, Ranipar and Asthuala Block Gagha in India, were faced with several problems such as profound poverty, deplorable health conditions, ecological degradation and waste management problems. Agriculture was the main occupation of the people, predominantly the cultivation of fruit trees. However, people had to cut down the fruit trees to meet their fuelwood demands for cooking and heating. A non-governmental organization, Sarvangeen Vikas Samiti, initiated a project called the 'Promotion of Sustainable Agricultural Activities through Demonstration of Bio-gas Plants and Other Allied Activities' in 2002 with the support of UNDP-SGP/GEF through the Centre for Environment. This project resulted in several socio-economic improvements. Broken down to the level of the single person, this means that a woman now saves three to four hours a day because she is using biogas as opposed to collecting fuelwood for cooking. Prior to using biogas, the bill for fuelwood was Rs 3900 to 4800 per annum, (about 80-110 USD); by using biogas, she now saves almost the entire amount.

All these success stories suggest that bioenergy has the potential to be effectively utilized to bring improvements to rural development and to alleviate poverty in communities. Given similar socio-economic conditions, these success stories could be replicated in areas with similar resources and conditions.

All the countries studied have policies that, at least notionally, encourage the penetration of bioenergy for rural

development and poverty alleviation. However, when it comes to comprehensive approaches, it is countries like South Africa and Mozambique that seem to have in place policies specifically targeting the use of bioenergy to bring about rural development and poverty alleviation. An overview of the bioenergy profile in eighteen countries and their policies and initiatives in support of bioenergy is provided in Table 1 (below).

Table 1: Summary of the bioenergy profile and policies in the selected study areas

Country and Study Focus	Bioenergy Profile	Policies and Initiatives in Place
Argentina (Reporting country)	<p>Biomass: Wood is an important biomass resource in Argentina. North East and North Central Argentina have access primarily to forest biomass resources, and the Mesopotamia region has abundant agro-industrial residue resources, mainly sawmill residues, rice husks and cotton residues. Bagasse is also used for co-generation in sugar mills.</p> <p>Biofuel: Argentina is a large biodiesel producer, with an estimated production of 1.9 million tons of biodiesel in 2010. Biodiesel production is largely based on soy, which occupies around 12% of arable land in Argentina.</p> <p>Biodiesel is also being used for grid power generation on a large scale.</p> <p>Biogas: Methane extraction from organic component of urban solid wastes. Buenos Aires produces 250 kW of electricity for self-consumption. Large agroindustries are beginning to use this energy source.</p>	<ul style="list-style-type: none"> • Level of development and political commitment is relatively high for biodiesel, medium for ethanol and very low for biogas and other biomass resources, particularly at low scales. • National law to promote biofuels and set mandatory targets of 5% for ethanol and 7% for biodiesel blends, as of July 2010. • GENREN programme offers incentives for power generation with renewable energies (focus on mid- to large-scale grid-connected projects).
Chile	<p>Co-generation: The country has 118 MW installed capacity using wood and forest residues and 73 MW installed capacity (2007) using black liquor.</p> <p>Biofuel: Keen interest in first generation biofuels (bio-ethanol and biodiesel). Additionally, Chile is supporting research on second-generation biofuels, mainly lignocellulosic ethanol and biodiesel from algae.</p> <p>Biogas: It is increasingly being produced by the industrial sector as a substitute for expensive natural gas. Also, this technology has been integrated into some sewage treatment plants.</p>	<ul style="list-style-type: none"> • Chile has authorized 2% and 5% biodiesel and bioethanol blends respectively, but due to the lack of first-generation feedstock and incentives, no production or imports existed as of 2010. • National Law 20257 mandating that 5% of electricity be generated from renewable sources, an obligation that binds commercialization agents. Between 2010 and 2014, the obligation is 5%; as from 2015, it should be increased yearly by 0.5%, reaching 10% in 2024. • National support programme for the development of advanced biofuels from forest biomass and algae.
Uruguay	<p>Co-generation: Biomass accounts for 1.4% of electricity inputs. 140 MW of electricity is generated from black liquor (a by-product of the pulp and paper industry).</p> <p>Biofuel: Uruguay aims to have a diversified feedstock supply for both biodiesel and ethanol production. The main target is local market supply.</p> <p>Biogas: There are pilot projects in dairy agro-industries.</p>	<ul style="list-style-type: none"> • Decree 77/06 for biomass-based electricity promotion. • Agrofuels law ('Ley de agrocombustibles' N 18.195 of 14/11/07) indicates blending percentages of 5% of alcohol (bio ethanol) in gasoline by 2015. For biodiesel, progressive incorporation of 2% biodiesel from 2009 to 2011, increasing to 5% from 2012.

Country and Study Focus	Bioenergy Profile	Policies and Initiatives in Place
Paraguay	<p>Traditional biomass: Fuelwood is an important biomass resource. Other important biomass resources in Paraguay come from vegetable residues, e.g. coconut and cotton. Fuelwood consumption is high among rural households, as it is used for the production of charcoal for both urban households and industries.</p> <p>Biofuel: Paraguay has an interest in developing its bioethanol and biodiesel industries.</p> <p>Paraguay has a biodiesel blend level close to 1% of diesel oil transport demand, mainly from animal fat feedstock. Bioethanol blend is close to 24%, mainly from sugarcane.</p>	<ul style="list-style-type: none"> • Promotion system for ethanol and biodiesel. • Tax exemption on import of flex-fuel cars.
Brazil (Reporting country)	<p>Co-generation: By the end of 2010, 7.8 GW (REN21, 2011) had been installed, generating a total of 28 TWh of electricity (IEA, 2011). Most generation is from Combined Heat and Power (CHP) plants at sugar mills using sugarcane bagasse as feedstock. During the 2010 sugar-harvesting season, sugarcane bagasse generated 18.5 TWh of electricity, including 8.8 TWh of excess electricity that was exported to the grid (Brazilian Ministry of Mines and Energy, 2011).</p> <p>Biofuel: Biofuels represent 19.6% of the national transportation fuel mix (MME, 2011), mainly ethanol from sugarcane and biodiesel from soybean oil, tallow and cotton oil. Brazil's ethanol production increased more than 7% in 2010 to 28 billion litres, and the country accounted for nearly one-third of the global total (REN21, 2011).</p> <p>In Brazil, biodiesel production increased 50% in 2010 to 2.3 billion litres, mostly in response to a domestic biodiesel blending mandate of 5% established in January 2010. By the end of 2010, there were 68 biodiesel plants operating in Brazil.</p>	<ul style="list-style-type: none"> • The Alcohol Program (1975), making ethanol production attractive to entrepreneurs by offering generous financing terms and competitive prices for ethanol. Nowadays, ethanol has become fully competitive with gasoline in the international market without further need of governmental assistance. The bioethanol blend is usually 25% (anhydrous ethanol - gasoline in volume basis). However, the recent shortage during this last season had led to the current bioethanol blend in Brazil being 20%. • It is part of the Brazilian biofuels program as mandated by the Federal Government to define the best blend depending on the prevailing circumstances. • Biodiesel Production and Utilization Program (2003) introducing a mandatory 5% blending of biodiesel to mineral diesel oil since 2010. • Environmental zonings, that define areas adequate for sugarcane crop without pressure on fragile biomes.
Colombia	<p>Co-generation: Sugarcane bagasse is used to produce electricity for own processing. Surplus energy is sold to the grid.</p> <p>Biofuel: Ethanol production from sugarcane was 327 million litres in 2009, 26% more than in 2008, but in 2010 production decreased to 287 million litres. Biodiesel production from palm oil was 172 million tonnes in 2009 and 343 million tonnes in 2010.</p>	<ul style="list-style-type: none"> • Colombian Biofuels Policy (2008) aims 'to increase biofuel production in a competitive and sustainable way'. • Bioethanol target of 10% blend in gasoline, and 5% biodiesel for 2009, increasing to 10% from 2010. • Tax incentives and tax-free areas for biofuel projects. • Decree 2629 (2007) established that from 2012 all new light vehicles must be equipped with Flex Fuel motors.

Country and Study Focus	Bioenergy Profile	Policies and Initiatives in Place
India (Reporting country)	<p>Co-generation: Co-generation projects exist mainly in the sugar industries. The generated power is used in the sugar mill, and excess electricity is exported to the grid. As of December 2010, 1495 MW of grid interactive bagasse co-generation infrastructure had been commissioned (MNRE, 2011).</p> <p>Traditional Biomass: Fuelwood is the dominant fuel, its consumption being estimated to be in the range of 162 to 298 million tonnes, followed by crop residue (37 to 156 million tonnes) and cattle dung (64 to 114 million tonnes). A rural household dependent on firewood for cooking and space heating consumes on average 118 kg of firewood and chips per month (NSS, 2011).</p> <p>The biomass power projects in the country are all private sector-driven. The total installed capacity of biomass gasifier systems as of December 2010 was 128 MW (MNRE, 2011).</p> <p>Biofuel: Biofuel development in India centres almost exclusively around the cultivation of <i>Jatropha curcas</i>.</p> <p>Biogas: Used for cooking in rural areas. About 4.3 million family-type biogas plants had been installed up to December 2010 (MNRE, 2011).</p>	<ul style="list-style-type: none"> • Policy focuses on market-based incentives and institutional support. • Biomass power and co-generation programme • Biomass Gasifier Programme • Fiscal incentives, concessional import duty and excise duty exceptions on equipment, tax holidays etc. are available for biomass power projects. • Biogas Based Distributed/Grid Power Generation Programme (2005-06) promoting biogas-based power generation, especially in the small capacity range using animal wastes and wastes from forestry, rural-based industries (agro / food processing), kitchen wastes, etc. • The National Project on Biogas Development (NPBD), which mainly caters to setting up family-type biogas plants, has been under implementation since 1981/82. • The Village Energy Security Programme (VESP), promoting bioenergy use in rural areas. • National Biofuels Policy (2008) aims at substituting 5% of transport (fossil fuel) diesel with bio-diesel by 2012, 10% by 2017 and 20% beyond 2017.
Kenya (Reporting country)	<p>Co-generation: Sugar factories have historically produced electricity from bagasse through their own production. Plans are underway in many sugar factories to upgrade their co-generation power plants in order to sell excess electricity to the national grid.</p> <p>Biofuel: Development of bioenergy as a substitute for fossil fuel (ethanol and biodiesel) is limited. Annual ethanol production is 17 million litres (primarily as an industrial additive and feedstock for the alcohol industry) against an estimated potential of 40 million litres per annum from sugar factories.</p> <p>Biogas: The number of biogas digesters installed at household level is estimated to exceed 1,100. The technical potential is estimated to be 1,259,000 units, translating to 300MW.</p>	<ul style="list-style-type: none"> • Sessional Paper No.4 of 2004 on Energy supports co-generation development. • The Energy Act of 2006 supports co-generation and promotes the use of renewable energy (including biomass). • A feed-in tariff (FiT) policy for electricity generated using biomass cogeneration was introduced in 2008 with a subsequent review in 2010 to make the feed-in tariff for co-generation more attractive. • Ethanol blending in petrol was tried in the 1980s after the second world oil crisis but was discontinued after world oil prices declined. Legal Notice No. 60 was enacted by the Minister for Energy in 2010, stipulating the regulations for the mandatory blending of ethanol with gasoline. • In 2006, the National Biofuels Committee established a focus on developing a biodiesel strategy using <i>Jatropha curcas</i>. • A Strategy for the Development of the Biodiesel Industry in Kenya (2008-2012) was published by the Ministry of Energy in 2008 to guide biodiesel development in Kenya. • A feed-in tariff (FiT) policy for electricity generated using biogas was introduced in 2010.

Country and Study Focus	Bioenergy Profile	Policies and Initiatives in Place
Mauritius	<p>Co-generation: Mauritius' co-generation development in the sugar industry is the most advanced in Africa. By the end of 2008, half of the electricity generated on the island came from sugar factories. Income from the sale of electricity became an important component of sugar industry revenue, thus enabling the sub-sector to weather periods of low world market prices for sugar better.</p>	<ul style="list-style-type: none"> • A Sugar Sector Strategic Plan (2001) was developed to enhance energy efficiency in milling, increase capacity and encourage co-generation investments. • A Roadmap for the Mauritius Sugarcane Industry for the 21st Century (2005) has been rolled out with the key objective of consolidating the country's sugar industry by reducing the number of sugar factories to enable the establishment of fewer, larger and more cost-effective sugar/co-generation industrial complexes.
Senegal (Reporting country)	<p>Traditional Biomass: The major source of energy in Senegal is fuelwood (and charcoal), which meets almost 60% of its final energy.</p> <p>Biofuel: Private <i>Jatropha</i> plantation initiatives are progressing on a highly decentralized basis without any proper national coordination. The country has a growing interest in bioethanol.</p>	<ul style="list-style-type: none"> • Quota system for charcoal production. • Promotion of biofuels as a substitute for petroleum products through its Energy Policy Paper (to cover 2007-2012 period) and its 'Return to Agriculture' Plan (REVA Plan). • National <i>Jatropha</i> Programme 2007-2012 (NJP) was launched in 2006, but the plan does not seem to be staying on the initially planned track defined in 2006. • Bioethanol production has been targeted with the installation of a processing plant within the Senegalese Sugar Company (CSS).
Ghana	<p>Traditional Biomass: Annual woodfuel production is estimated at 18 million tonnes. Large amounts of potential energy resources in the form of agricultural residues and municipal waste remain untapped.</p> <p>Biofuel: Production of biodiesel from <i>Jatropha curcas</i> has attracted a lot of interest in Ghana. At least 3 million hectares of land has been either put aside or earmarked for <i>Jatropha</i> cultivation by private-sector companies. Another 1 million hectares of land has been estimated to be the land requirement for implementing the National <i>Jatropha</i> Plantation Project (NJPP). Sunflower is being explored on a smaller scale as feedstock for biodiesel production.</p> <p>Biogas: A little over 100 biogas plants have been installed in Ghana to date. The majority of these plants are bio-sanitation interventions such as waste/effluent treatment plants and bio-latrines, which are largely located in educational and health institutions in predominantly urban areas. There are a very limited number of domestic biogas plants in Ghana.</p>	<ul style="list-style-type: none"> • A Draft Bioenergy Policy for Ghana was launched by the Energy Commission in August 2010. • National Renewable Energy Law has just being passed by parliament.

Country and Study Focus	Bioenergy Profile	Policies and Initiatives in Place
Mali	<p>Traditional biomass: The share of bioenergy in the country energy balance is around 70%; however, its use is still made in a traditional and non-efficient manner (wood, charcoal, residues). The total consumption of charcoal is close to 60,000 tonnes per year, the equivalent of converting 300,000 tonnes of wood.</p> <p>Biofuel: Mali is today the most experienced country in West Africa in the field of electricity generation from <i>Jatropha</i>. E.g. rural electrification from <i>Jatropha</i> biodiesel is providing electricity to 250 subscribers in Garalo, Mali.</p>	<ul style="list-style-type: none"> National Energy Policy (2006). National Strategy for the Development of Biofuels. Governmental Programme for the Promotion of <i>Jatropha</i> in Mali.
South Africa (Reporting country)	<p>Traditional biomass: About 80 percent of the population in rural areas depend on fuelwood as their primary energy source for heating and cooking. In South Africa charcoal is not commonly used for household thermal uses.</p> <p>Biofuel: There are small biodiesel plants in operation using predominantly waste vegetable oil. Some farmers also produce biodiesel from sunflower seeds for their own on-farm use. Sugar companies produce ethanol from sugarcane on a limited scale for end-uses such as alcohol, but not for fuel.</p>	<ul style="list-style-type: none"> White Paper on the Renewable Energy Policy of South Africa (2003). Additional 10,000 GWh of renewable energy contribution (3% of total) to final energy consumption, mainly from biomass, solar and small-scale hydro, by 2013. The Biofuels Industrial Strategy (2007) supports biofuel for social development and poverty alleviation. It proposes sugarcane and sugar beet for ethanol production and sunflower, and canola and soya beans for biodiesel. Renewable Energy Feed-in Tariff (2009) includes support for biomass and biogas.
Mozambique	<p>Traditional Biomass: Wood is the predominant fuel in rural areas, and charcoal is more common in urban areas. About 84% of the population rely on wood and charcoal.</p> <p>Biofuel: Sugarcane and sweet sorghum are the proposed feedstocks for bioethanol and <i>Jatropha curcas</i> and coconut for biodiesel. In addition to producing ethanol, the sugarcane industry has the potential to combust bagasse residues from sugarcane processing for heat and electricity.</p>	<ul style="list-style-type: none"> Mozambique is developing biofuels at two levels: plantations with the assistance of foreign investment, and government-supported smallholders to address poverty alleviation and rural development. Biofuel Policy and Strategy (2009). This policy includes blending targets for the national market for three periods. In the <i>Pilot phase (2009-2015)</i>, increase the level of blending up to 10% ethanol (E10) and up to 5% biodiesel (B5). <i>Operational phase (2015-2021)</i>: E10 and B5 will be available nationwide and if possible blending will be increased to E20 and B20. <i>Expansion phase (from 2021)</i>: Development of parallel distribution network for blending above E25 and B75 aiming at E100 and B100. National Programme for Biofuel Development providing financial support for biofuel activities and projects.

Country and Study Focus	Bioenergy Profile	Policies and Initiatives in Place
Malawi	<p>Traditional Biomass: Biomass contributes over 95% of primary energy supply in Malawi, and fuelwood and charcoal supply most of this demand.</p> <p>Biofuel: Malawi is the only country in the South African region producing bioethanol for blending with petrol (E10). The government has supported ethanol production and blending since 1982. Two privately owned companies generate 18 million litres of ethanol from sugarcane per year, of which 95% is used for fuel-ethanol blending and 5% for industrial alcohol. <i>Jatropha</i> is widely encouraged as feedstock for biodiesel, and several projects growing <i>Jatropha</i> are underway, grown by both smallholder farmers and on plantations.</p>	<ul style="list-style-type: none"> • National Environmental Policy dealing with fuelwood, charcoal and biofuels to prevent further degradation of forests and to minimize dependence on imported oil. • National Energy Policy (2003). • Malawi Growth and Development Strategy (2006-2011). Six key priority areas including energy generation and supply. • No specific biofuel policy
Thailand (Re-reporting country)	<p>Biomass: Agricultural residues from paddy (rice husk, rice straw) and sugarcane (bagasse) are used for electricity generation by Small Power Producers (SPP) and Very Small Power Producers (VSPP). The installed capacity as of 2011 was 1,457 MW, of which approximately half was sold to the national grid.</p> <p>Biofuel: Cassava and sugarcane are the two major types of feedstock for ethanol production in Thailand. Biodiesel production has increased significantly from 68 million litres in 2007 to 610 million litres in 2009, mainly from palm oil. As of March 2010, there were 14 biodiesel production plants with a total capacity of (B100) 5.9 million litres a day.</p> <p>Biogas: The installed capacity of biogas for electricity generation in Thailand is about 10.6 MW (2009).</p>	<ul style="list-style-type: none"> • Fund to provide developers with assistance to cover the differential cost between production and the market price of biomass power. • Tax incentives to promote renewable energy. • Very Small Power Producer Programme allowing power producers with sale to the grid of less than 1 MW to come under a more lenient set of requirements and less complicated power purchase arrangement. • Renewable Portfolio Standard requiring all power producers to produce 5% of their installed energy-generating capacity from renewable sources. • Investment promotion incentives provided to manufacturers of ethanol.

Country and Study Focus	Bioenergy Profile	Policies and Initiatives in Place
Indonesia	<p>Biofuel: Ethanol production in Indonesia was about 144 million litres in 2008, and the economy plans to reach 6.3 billion litres in 2025. Biodiesel production in 2008 was about 1,238 million litres and it is estimated to reach 10.2 billion litres in 2025. There were 237 biofuel-based Energy Self-Sufficient Villages as of July 2009.</p>	<ul style="list-style-type: none"> • National Energy Policy (2006) includes a target of increasing use of biofuel to more than 5%. • Development of bio-energy and making available 60,000 km² of new plantation area for sugarcane, cassava, palm and <i>Jatropha cultivation</i>. • The Government of Indonesia has designated special biofuel zones and designed the concept of an energy self-sufficient village. • Value-added tax (VAT) reductions for biofuel businesses and excise duty cuts for biofuels users. • In 2007, the government announced an interest rate subsidy of Rp 1 trillion (111 million USD) for farmers growing biofuel crops, including <i>Jatropha</i>, oil palm, cassava and sugarcane. • Loans at an interest rate of almost half the market rate can be obtained for farmers of cane, cassava, palm, rubber and coconut.
China (Reporting country)	<p>Biopower generation: By the end of 2010, the total capacity of biopower projects was 6.7 GW, from sugarcane bagasse and straw- and MSW-based power-generation projects.</p> <p>Biofuel: Biodiesel production (mainly from waste cooking oil) reached 0.4 million tons and bio-ethanol production reached 1.8 million tons in 2010. Biofuel technology using cassava, sweet sorghum, <i>Jatropha curcas</i> and other non-food crops or plants has entered the stage of demonstration.</p> <p>Biogas: Approximately 14 billion cubic metres of biogas are generated in more than 1600 large-scale projects and more than 30 million small-scale household projects, amounting to 0.71GW of electricity from biogas (also from waste incineration).</p>	<ul style="list-style-type: none"> • Renewable Energy Law (2006) and Mid- and Long-term Plan for Renewable Energy (2007) focusing specifically on renewable energy, including bioenergy. • Since July 2010, newly grid-connected biopower projects using agricultural and forestry residue in China are eligible for the same fixed feed-in tariff of 0.75 RMB (0.11 \$)/kWh continuously for the next 15 years since commencing operation. However, the co-fired generation plants using more than 20 percent of traditional fuel (such as coal) are classified as traditional power plants rather than biopower plants, and are ineligible for the FiT. All other types of biopower plants making use of biomass waste are eligible for a VAT refund. • Bio-industrial development 11th Five-Year Plan (2006-2010).

Sustainability concerns associated with bioenergy

So far most of the sustainability concerns focus on biofuels, especially those from food-derived sources, which are generally referred to as first-generation biofuels. However, many of the concerns are also of relevance to other feedstocks and end products. The sustainability debate is broadening out from biofuels towards general bioenergy and including by-products such as biomaterials. The sustainability concerns associated with biofuels include:

- direct greenhouse gas emissions (direct emissions) and indirect emissions emanating from land use changes
- net energy balances
- water consumption
- food security
- biodiversity
- impact of agrochemicals on human health and ecosystems
- long-term soil quality and conservation
- social impacts (employment patterns, traditional livelihoods and population displacement)
- fiscal impacts and distribution of benefits
- deforestation of natural areas

It is therefore important for sustainability criteria to be taken into consideration when countries try to develop their bioenergy sectors (Ackom *et. al.*, 2010). This is because the ongoing sustainability debate and the criteria being developed provides immense opportunities for bioenergy to be done correctly, thus providing preconditions for the acceptability and long-term development of the sector itself. It was found that the countries studied were at different levels with regards to regulations for bioenergy sustainability. For example, countries like Brazil and China are quite advanced with regard to regulations for bioenergy sustainability requirements.

The Brazilian example is a very interesting one, for several reasons. While the Alcohol Programme started initially to reduce expenditure on oil imports, it turned out to have spurred a new industry sector, with employment creation as well as agricultural and industrial development. At the same time, it soon became apparent that the environmental and social aspects associated with sugarcane-ethanol production needed to be addressed too. Since then, major policies on bioenergy sustainability have been established and implemented. This includes legislation banning cane-field burning, dealings with vinasse and the federal/states zoning of land used for sugarcane production in the country, aimed at protecting fragile ecosystems (namely *Amazo-*

nia, Pantanal, Brazilian savannah – cerrado, Rain Forest).⁴

China attaches great importance to the sustainability of bioenergy, especially liquid biofuel derived from grain, sugar and vegetable oil. In 2006, the Chinese government stated clearly that biofuel production must follow the principle of:

- no competition with food
- no competition with arable land, and
- no harm to the natural environment and ecosystem.

As a result, new projects for ethanol production from corn or wheat as well as biodiesel from edible oil (such as rapeseed oil) have been strictly prohibited in China since 2006. The Global Bioenergy Partnership (GBEP) has been working since 2008 to provide empirically based bioenergy sustainability criteria. It recently endorsed a set of 24 voluntary sustainability indicators for bioenergy that covers all essential aspects of bioenergy including environmental, social and economical issues. Although there exist a number of similar initiatives, GBEP's uniqueness lies in the fact that it also attempts to build consensus on bioenergy sustainability among governments and international institutions in addition to the development of empirical measurements useful for national-level policy analysis (GBEP, 2011). Some of the countries selected in this study, which are part of GBEP, include Argentina, Brazil and Ghana. The Economic Community of West African States (ECOWAS) is also a member of GBEP for which the following countries covered in this study form part, namely Senegal, Mali and Ghana. Involvement in GBEP as observers includes Mozambique, Chile, India, Indonesia, Kenya, South Africa and Thailand. The Economic Commission for Latin America and the Caribbean (ECLAC) is an observer in GBEP. Chile, Uruguay, Paraguay and Colombia covered in this study are members of ECLAC, (together with Argentina and Brazil).

Though sustainability is being mentioned broadly in most national programmes, there are very limited requirements or regulations to support it. For example, even though governments have concerns regarding the use of fertile lands for biofuel production, there are limited to no clear sustainability regulations to guide foreign investors who are interested in acquiring land for bioenergy development. The ongoing sustainability discussions provide an

4 see <<http://mapoteca.cnps.embrapa.br/>>

opportunity for bioenergy to be done correctly, but the lack of sustainability regulations and enforcement in nations might lead to land-grabs of agricultural, ecological and/or culturally sensitive areas for bioenergy production. Additionally, it has been observed that foreign investor interest in bioenergy development often surprised developing countries (UN-Energy 2010). These nations are often 'unprepared' in terms of having sufficient policies, legislation and enforcement in place to ensure the overall sustainability of bioenergy even though bioenergy investments could play a role in achieving national development goals. Developing countries and emerging economies should therefore improve their policies, legislation, regulation and enforcement on bioenergy sustainability as there exist significant interest and investment opportunities in the sector.

The country reports underlying this summary for policy-makers have also attempted to identify some of the major barriers, including finance, agricultural extension services and governance that hinder investor security, licensing processes, land tenure and consequently the widespread dissemination of bioenergy in developing and emerging economies. They have been summarised in Table 2 (next page).

Table 2: Barriers to utilizing bioenergy in developing countries/emerging economies and policy options

	Identified barriers	Policy options
Co-generation	<p>1. Flexible feed-in tariff. Fixed feed-in tariff policies have spurred interest in the development of co-generation in some of the countries studied, such as Brazil⁵ and India. However, the lack of a 'fixed' feed-in tariff in certain countries, e.g. Kenya, implies that an investor in co-generation has to negotiate with the distribution utility⁶.</p> <p>2. Non-enforceable legal and regulatory instruments. Since co-generation investments are long term in nature, it is imperative that the existing and future legal and regulatory instruments are enforceable by a court of law. The recent experience of Mumias Sugar in Kenya, where the distribution utility has not been providing priority dispatch as required by the feed-in tariff policy, could discourage co-generation development in the country.</p> <p>3. Lack of technical expertise. Due to the limited experience in co-generation development in some of the studied countries, there is limited expertise available on co-generation development. The skills gap ranges from a lack of experts to carry out comprehensive and bankable feasibility studies and engineering studies to a lack of the expertise required for the construction, installation, commissioning and maintenance of advanced co-generation equipment such as steam turbines and high-pressure boilers, as well as gasifiers³.</p> <p>4. Unavailable local financing: While nearly all sugar factories bank with local commercial banks and, in some cases, enjoy healthy business ties, unfortunately local commercial banks do not have the experience or technical capacity to conduct the requisite due diligence to finance co-generation plants. Consequently, sugar factories have to seek investment financing from regional and international development financing institutions, which are not as familiar with the operations in the host country's sugar factories, thus complicating the process of raising investment finance for co-generation.</p>	<p>1. Instituting a pre-determined feed-in tariff for bio-energy power plants. This eliminates the notion of negotiation with the utility, which could be a lengthy and difficult process. Additionally, a power purchase agreement, linked to a pre-determined standard-offer or feed-in tariff and issued by the national utility to purchase all energy produced by co-generation plants, can be instrumental in the successful scaling up of bio-energy investments.</p> <p>2. Policy reform to strengthen the enforcement of legal and regulatory instruments. Such policy reforms will be essential to boost investor confidence to engage in capital-intensive bioenergy initiatives.</p> <p>3. Skills transfer (capacity-building). For example, capacity-building could be achieved through technical cooperation with other developing and emerging countries such as Mauritius, India and Brazil with good experience in co-generation development. Other initiatives such as the Cogen for Africa project (http://cogen.unep.org) are available to provide support especially to African countries.</p> <p>4. Innovative financing schemes should be developed by financial institutions (especially local commercial banks) in collaboration with project developers. Interaction between financiers and project developers could help bridge the knowledge gap on both sides. Financiers would gain a better understanding of co-generation technologies, while project developers would have a better appreciation of the prerequisites for raising finance for co-generation investments.</p> <p>Developing countries could possibly tap into the various international and regional initiatives that can provide funding for bioenergy projects. These initiatives include the Global Environment Facility (GEF) and the Kyoto Protocol's Clean Development Mechanism (CDM). One drawback of the CDM, however, is its high transaction costs and specialized skills requirements, which have tended to limit the participation of African countries such as Kenya. There are useful lessons to be learnt by Kenya and other African countries from the experiences of India, China, Brazil and Mexico on how to expedite CDM co-generation projects.</p>

⁵ This however does not exist anymore in Brazil

⁶ In Brazil all investors now negotiate with the utilities

	Identified barriers	Policy options
Co-generation	<p>5. Lack of availability of commercial low-scale technology⁷.</p> <p>6. Lack of support infrastructure in some regions.</p> <p>7. High investment costs not affordable by poor small rural communities.</p>	<p>5. Support the development of low-scale technologies on a commercial scale and develop market volume.</p> <p>6. Support projects built around existing rural enterprises that produce biomass resources.</p> <p>7. Government subsidies and incentives to help reduce the high initial investment costs.</p>
Biofuel (For the biofuel industry to be consolidated as an energy commodity in the international market and to achieve production and marketing increases requires overcoming some identified barriers, such as):	<p>1. It is essential to have several countries as suppliers and consumers.</p> <p>2. However, the current high investment costs in terms of raw materials, enzymes and processing are a challenge⁸.</p> <p>3. Subsidies and protectionism. These have been mentioned as producing distortions in international trade, preventing the free flow of products and limiting the market to occasional transactions when there are deficiencies in supply. Protectionism is especially acute where biofuels are promoted to help domestic farmers in high-cost producing countries. It has been suggested that subsidies could potentially have impacts on environmental sustainability, as they sometimes tend to promote less efficient energy crops with the lowest greenhouse gas reductions (Dufey, 2006).</p> <p>4. Certification issues can also be a non-tariff barrier, despite the fact that they are important to guarantee the sustainability of biofuels production and use. For Least Developing Countries (LDC), where the lack of funding and of adequate capacity-building are key factors, this is a huge barrier to biofuel exports to industrialized countries (UNCTAD, 2008).</p>	<p>1. Policies to support and promote biofuels. For example, biofuel production from sugarcane is considered economically viable even without subsidies.</p> <p>2. Increased support for research and development is required to help bring down the initial high investment costs.</p> <p>3. Reconsidering subsidies and protectionism to support the global growth of the biofuel industry.</p> <p>4. Biofuels must have specifications (standardisation) and possibly also be required for production certification, but adapted to the real conditions of each region. Adequate capacity-building and funding are essential for developing biofuel programmes in Least Developed Countries (LDC's).</p>
Biogas	<p>1. High capital costs to install biodigesters has been mentioned as a predominant reason limiting large-scale dissemination of the technology.</p> <p>2. In some regions, there is a lack of experience, standardization and support infrastructure.</p>	<p>1. Incentives or subsidies by governments to help reduce the high initial capital cost as well as promoting and supporting pilot and demonstration projects. Cost reductions could be achieved with time through learning.</p> <p>2. Need for capacity building and experience sharing.</p>

⁷ Technology available only on small scale in few countries such as India and Brazil. Not yet available in large commercial scales'.

⁸ This is especially the case for second generation biofuel conversion technology. Cost reductions are however expected to occur over time as a result of advancements in technological know-how'

Policy recommendations and conclusions

An effective way of alleviating poverty is through the energization of productive activities in order to improve quality of life and incomes. This study undertaken by the GNESD Centres of Excellence has shown that, depending on the scale, bioenergy technologies require high organisational efforts and a minimum level of infrastructure, income and knowledge, elements that must be developed in most of the rural sector of several developing countries and emerging economies. Finally and most importantly, the introduction of these technologies can help poor rural people when they are integrated into a comprehensive development strategy.

The main barrier to the use of biomass as fuel in the commercial or industrial sector, as well as for power generation, is its high investment cost, low conversion efficiency, difficulties in transportation, seasonal dependency and moisture content. To mitigate the above barriers, countries need to consider not only technological improvements through increased conversion efficiency⁹, but also technology transfer and capacity-building in operation and maintenance, especially in rural communities.

Based on the findings of the study, the following policy recommendations are proposed for consideration:

1. Countries must take sustainability concerns into consideration when developing policies and programmes for bioenergy. In particular, long-term supports (investor security/visibility) as well as mapping/zoning have proved crucial in the Brazilian experience. The effective implementation of such policies, including sustainability criteria, requires appropriate processes and institutions to be put into place, as well as regular monitoring and verification.
2. Setting-up supporting regulatory frameworks to ensure sustainable production and use of bioenergy at the environmental, economic and social levels.
3. Instituting sustainability approaches to help insure the sustainable production and use of bioenergy. This will safeguard the livelihood systems of the poor and vulnerable.
4. Implementing sustainability approaches that should primarily targets the in-country production, processing and uses of bioenergy and ensure the improvement of local populations' livelihoods and energy and food security.
5. An assessment of the quantity, geographical distribution and accessibility to biomass, as well as any potential competition with other industries for the resource need to be evaluated before commencing any bioenergy initiatives.
6. Increased national support for research and development (R&D) in high crop-yield plant-breeding. This together with adequate environmental legislation, has the added benefit of reducing land use and deforestation problems.
7. Governments should increase their investments in research and development (R&D) of bioconversion activities and provide support to reach the commercial stage.
8. A dedicated institution for bioenergy research, development and promotion should be 'carved' out of the existing national institutional maze of multiple organizations with overlapping roles in most developing countries. At the same time, it is important that the dedicated research, development and promotion institution has sufficient ties to existing institutions to ensure integration and also to maximize the opportunities presented by the various organizations.
9. Integrating the bioenergy industry into existing industries. Such creative inter-linkages would ensure that the existing opportunities and infrastructure are tapped to achieve resource efficiency.
10. Establishing a successful bioenergy industry needs a high degree of organizational effort and a minimum level of infrastructure, income and knowledge; elements that still have to be developed in most of rural sectors in emerging economies and developing countries.

⁹ Technological improvements through increased conversion efficiency have been experienced in Brazil in its biofuels and cogeneration initiative as well as in Mauritius and India (cogeneration). Similar experience seems to be occurring in Kenya and Uganda (cogeneration through the Cogen for Africa initiative).

11. Develop and implement national bioenergy policies. Such policies should set clear and realistic targets for bioenergy in the national energy mix and develop strategies, including proper incentive mechanisms to help achieve set targets.
12. Ensuring transparency in bioenergy financial resources allocation. To put in place supporting measures to enhance the capacity to implement the sustainability of bioenergy and promote environmentally and socially friendly bioenergy markets.
13. A market approach could be used to promote technology transfers on a self-sustainable basis, rather than remaining dependent on 'one time' grants. This should be the case for technologically matured bioenergy options.
14. Innovative financing schemes should be explored to finance bioenergy projects.
15. Innovative revenue-sharing mechanisms should be considered if bioenergy (such as co-generation) is to be utilized as an effective poverty alleviation tool. An example is the equitable sharing of proceeds from the sale of co-generated electricity among the stakeholders (including the small-scale farmers who provided the sugarcane) as practised in Mauritius. Another example is to use some of the revenue from co-generated electricity to provide social amenities such as health posts, schools and clean water, as well as improving road networks in rural areas, as is being done by sugar mills in Kenya.
16. Implementing incentives for the adequate development of regional support networks for each technology; promoting and supporting association among very small producers; promoting the commercial availability of small scale-biomass technologies.
17. Integrating biomass energy support policies into wider development policies to ensure coherence in objectives and efficient use of resources. This helps to assign priority levels, identify bottlenecks and complement measures (e.g. rationale energy use in the transport sector and biofuel promotion).
18. The promotion and dissemination of high efficiency cookstoves and the use of biomass briquettes and pellets from sustainably derived agricultural and forest/wood residues.

In conclusion, the use of traditional biomass for cooking and heating is prevalent in rural communities in developing countries. The price to be paid for continuous dependence on traditional biomass for cooking and heating could be very high in terms of human health (even lives), the negative impact on academic performance and the loss of ecosystem services. However, there are alternatives to the use of traditional biomass such as bioenergy, which can provide clean and reliable energy services if done well. The result is a better quality of life socio-economically, better health and improved academic performance by children being able to study for longer hours due to modern lighting. This summary for policy-makers has provided case studies where bioenergy has been employed in the process of helping to achieve rural development and poverty alleviation. There are still several barriers hindering the uptake and diffusion of bioenergy technologies in developing countries, but with the right policies, local organizational structures and capacity-building, bioenergy could certainly play an effective role in rural development and poverty alleviation.

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